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Microsponge: An augmented drug delivery system

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ABSTRACT

Microsponges are polymeric delivery systems composed of porous microspheres. They are tiny sponge-like spherical particles with a large porous surface. Moreover, they may enhance stability, reduce side effects and modify drug release favorably. Microsponge technology has many favorable characteristics, which make it a versatile drug delivery vehicle. Microsponge Systems are based on microscopic, polymer-based microspheres that can suspend or entrap a wide variety of substances, and can then be incorporated into a formulated product such as a gel, cream, liquid or powder. The outer surface is typically porous, allowing a sustained flow of substances out of the sphere. Microsponges are porous, polymeric microspheres that are used mostly for topical use and have recently been used for oral administration. Microsponges are designed to deliver a pharmaceutical active ingredient efficiently at the minimum dose and also to enhance stability, reduce side effects, and modify drug release. The aim of this article is to provide detail about microsponges and the past work done on it. Microsponge delivery system consisting of a polymeric bead having network of pores with an active ingredient held within. Microsponge was developed to provide controlled release of the active ingredients whose final target is skin itself. Microsponge delivery system can be prepared into conventional dosage forms such as creams, lotions, gels, ointments, and powder and share a broad package of benefits. It holds a promising future in various pharmaceutical applications in the coming years. This review article consists of full detail on microsponge and different types of drug formulated in microsponge.

Keywords: Microsponge, drug delivery, augmentation, marketed products

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INTRODUCTION

The Microsponge Delivery System (MDS) is a patented polymeric system consisting of porous microspheres. They are tiny sponge like spherical particles that consist of a myriad of interconnecting voids within a non-collapsible structure with a large porous surface through which active ingredient are released in a controlled manner (Figure 1). The size of the microsponge ranges from 5-300µm in diameter and a typical 25µm sphere can have up to 250000 pores and an internal pore structure equivalent to 10 feet in length, providing a total pore volume of about 1ml/g for extensive drug retention. The surface can be varied from 20 to 500 m^2/g and pore volume range from 0.1 to 0.3cm^3/g. This results in a large reservoir within each microsponge, which can be loaded with up to its own weight of active agent [1]. Microsponges are microscopic spheres capable of absorbing skin secretions, therefore reducing oiliness and shine from the skin. Spherical particles composed of clusters of even tinier spheres are capable of holding four times their weight in skin secretions. Microsponge polymers possess the versatility to load a wide range of actives providing the benefits of enhanced product efficacy, mildness, tolerability, and extended wear to a wide range of skin therapies [2].

Figure 1: Structure of microsponge

Microsponges consisting of non-collapsible structures with porous surface through which active ingredients are released in a controlled manner. Microsponges are porous microsphere having interconnected voids of particle size range 5- 300µm (Figure 2). They are uniform, spherical polymer particles. Their high degree of cross-linking results in particles that are insoluble, inert and of sufficient strength to stand up to the high shear commonly used in manufacturing. Microsponges are designed to deliver a pharmaceutically active ingredient efficiently at minimum dose and also to enhance stability, reduce side effects, and modify drug release profile [3].

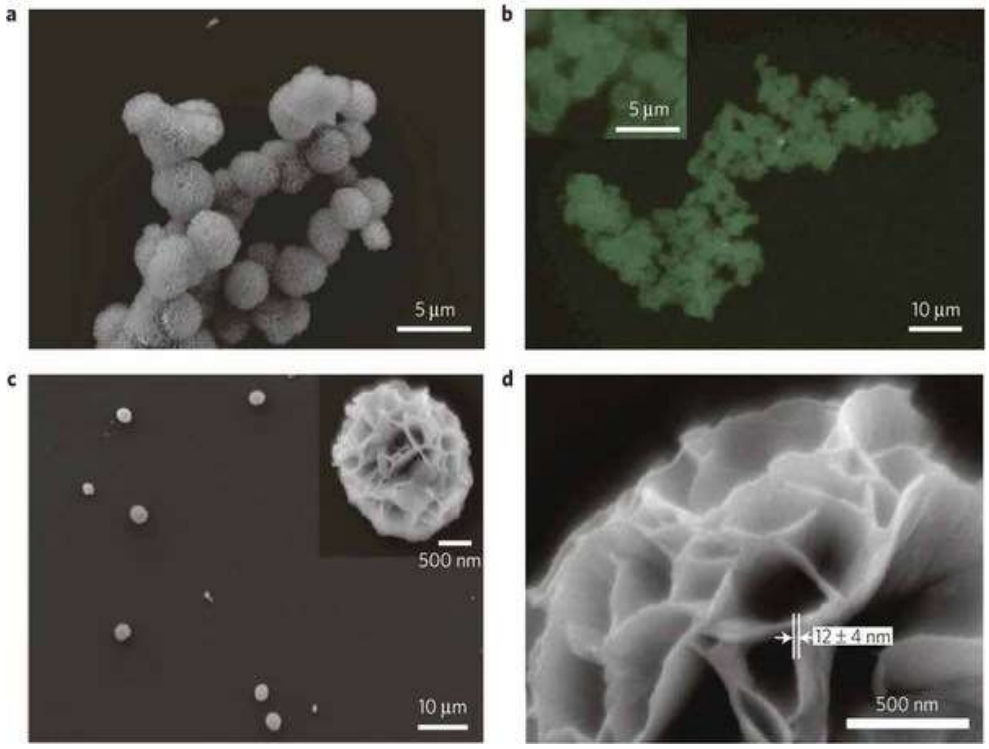

Figure 2: Different sizes of microsponges

Advantages [4]

- Advanced oil control, absorb up to 6 times its weight without drying.
- Extended release.
- Reduced irritation formulas.
- Allows novel product form.
- Improved product aesthetics.
- Extended release, continuous action up to 12 h.
- Reduced irritation, better tolerance means broader consumer acceptance.
- Improved product aesthetics, gives product an elegant feel.
- Improves stability, thermal, physical and chemical stability.
- Allows incorporation of immiscible products.
- Improves material processing eg. liquid can be converted to powders.
- Allows for novel product forms.
- Improves efficacy in treatment.
- Cure or control confirm more promptly.
- Improve control of condition.
- Improve bioavailability of same drugs.

Characteristics of microsponges [5]

- Formulations are stable over range of pH 1 to 11.
- Microsponge formulations are stable at the temperature up to 130^{o}C.
- Microsponge formulations are compatible with most vehicles and ingredients.
- Microsponge formulations are self-sterilizing as their average pore size is 0.25µm where bacteria cannot penetrate.
- Microsponge formulations have higher payload (50-60%), still free flowing and can be cost effective.

Properties of the actives for the entrapment into the microsponge [1]

- It should be either fully miscible in monomer or capable of being made miscible by addition of small amount of a water immiscible solvent.
- It should be water immiscible or at most only slightly soluble.
- It should be inert to monomers and should not increase the viscosity of the mixture during formulation.
- It should be stable when in contact with polymerization catalyst and under conditions of polymerization.
- The spherical structure of the microsponges should not collapse.

Various polymers like Eudragit RS100, Ethyl Cellulose, Polystyrene and PHEMA can form a microsponge "cage". In addition to actives; some microsponges contain plasticizers like Triethylcitrate (TEC) that help to stabilize their structure.

Method of preparation [6]

Liquid–liquid suspension polymerization

In general, a solution is made comprising of monomers and the functional or active ingredients, which are immiscible with water. This phase is then suspended with agitation in an aqueous phase, usually containing additives, such as surfactants and dispersants, to promote suspension. Once the suspension is established with discrete droplets of the desired size, polymerization is effected by activating the monomers either by catalysis, increased temperature or irradiation. As the polymerization process continues, a spherical structure is produced containing thousands of microsponges bunched together like grapes, forming interconnecting reservoirs Figure 3.

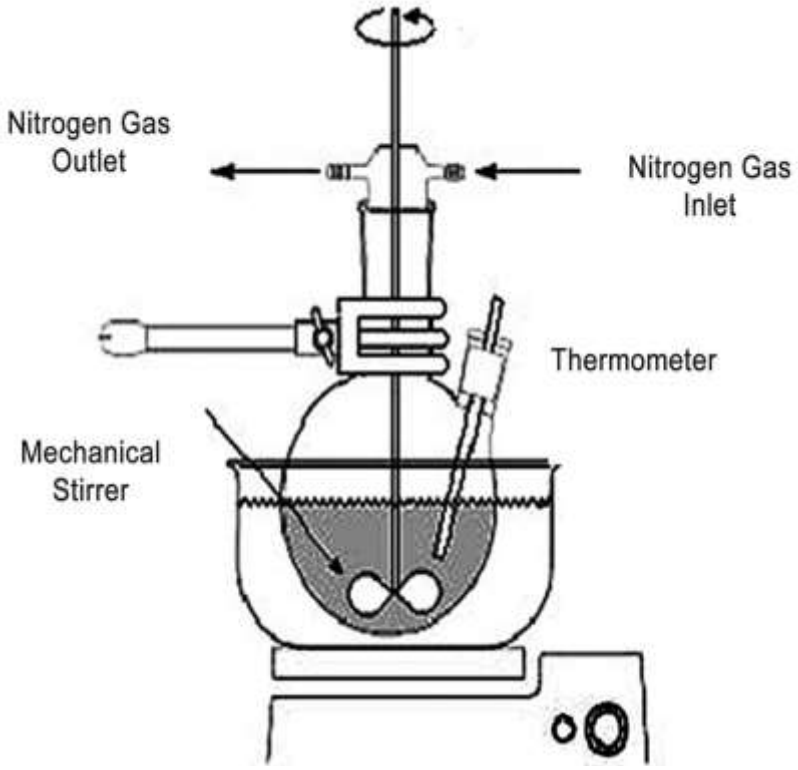

Figure 3: Reaction vessel for microsponge preparation by liquid–liquid suspension polymerization

Once the polymerization is complete the solid particles that result from the process are recovered from the suspension. The particles are then washed and processed until they are substantially ready for use. The microsponge products can be made using styrene and divinylbenzene or methyl methacrylate and ethylene glycol dimethacrylate as starting materials.

Quasi-emulsion solvent diffusion

To prepare the inner organic phase, Eudragit RS 100 is dissolved in ethyl alcohol. Next, the drug is added to the solution and dissolved under ultrasonication at 35^{o} C. The inner phase is poured into the polyvinyl alcohol solution in water (outer phase). Following 60 min of stirring, the mixture is filtered, to separate the microsponges. The microsponges are dried in an air-heated oven at 40^{o}C for 12 h Figure 4.

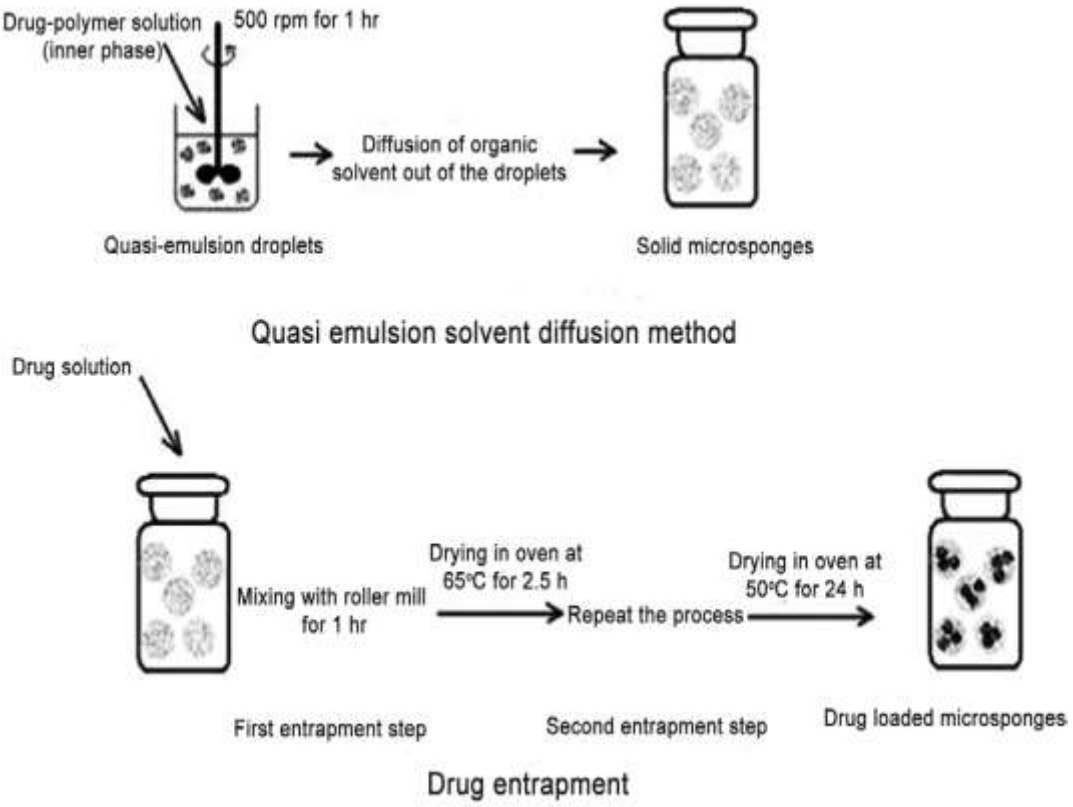

Figure 4: Preparation of microsponges by the quasi-emulsion solvent diffusion method

Ingredients can be entrapped in microsponge polymers either at the time of synthesis, or if too labile to withstand polymerization conditions, they can be post-loaded after the microsphere structure has been pre-formed. In general, the latter process is the preferred mode, as many cosmetic ingredients, and most pharmaceutical ones, would decompose at the temperatures employed for polymerization.

Hypothetical mechanism of action [6]

The active ingredient is added to the vehicle in an entrapped form. As the microsponge particles have an open structure (i.e., they do not have a continuous membrane surrounding them), the active is free to move in and out from the particles and into the vehicle until equilibrium is reached, when the vehicle becomes saturated. Once the finished product is applied to the skin, the active that is already in the vehicle will be absorbed into the skin, depleting the vehicle, which will become unsaturated, therefore, disturbing the equilibrium (Fig 5). This will start a flow of the active from the microsponge particle into the vehicle, and from it to the skin, until the vehicle is either dried or absorbed. Even after that the microsponge particles retained on the surface of the stratum corneum will continue to gradually release the active to the skin, providing prolonged release over time. This proposed mechanism of action highlights the importance of formulating

vehicles for use with microsponge entrapments. If the active is too soluble in the desired vehicle during compounding of the finished products, the products will not provide the desired benefits of gradual release. Instead they will behave as if the active was added to the vehicle in a free form. Therefore, while formulating microsponge entrapments, it is important to design a vehicle that has minimal solubilizing power for the actives. This principle is contrary to the conventional formulation principles usually applied to topical products. For these conventional systems it is normally recommended to maximize the solubility of the active in the vehicle. When using microsponge entrapments, some solubility of the active in the vehicle is acceptable, because the vehicle can provide the initial loading dose of the active until release from the microsponge is activated by the shift in equilibrium from the polymer into the carrier.

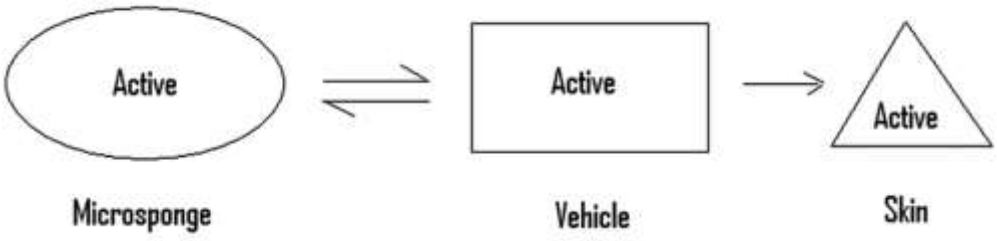

Figure 5: Schematic representation of the distribution of the loaded material (active) on skin

Another way to avoid undesirable premature leaching of the active from the microsponge polymer is to formulate the product with some free and some entrapped active, so the vehicle is pre-saturated. In this case there will not be any leaching of the active from the polymer during compounding. The rate of active release will ultimately depend not only on the partition coefficient of the active ingredient between the polymer and the vehicle (or the skin), but also on some of the parameters that characterize the beads. Examples of these include surface area and primarily, mean pore diameter. Release can also be controlled through diffusion or other triggers such as moisture, pH, friction or temperature.

Mechanism of drug release [7]

Microsponge can be designed to release given amount of active ingredients over time in response to one or more external triggers.

Temperature Change: At room temperature, few entrapped active ingredients can be too viscous to flow suddenly from microsponges onto the skin. With increase in skin temperature, flow rate is also increased and therefore release is also enhanced.

Pressure: Rubbing or pressure applied can release the active ingredient from microsponges onto skin.

Solubility: Microsponges loaded with water miscible ingredients like antiseptics and antiperspirants will release the ingredient in the presence of water. The release can also be activated by diffusion but taking into consideration, the partition coefficient of the ingredient between the microsponges and the external system.

pH Triggered Systems: Triggering the pH-based release of the active can be achieved by modifying the coating on the microsponge. This has many applications in drug delivery.

Evaluation parameters of microsponges [4]

- Particle size (Microscopy)
- Morphology and Surface topography
- Loading efficiency and production yield
- Resiliency
- Compatibility studies
- Drug release study

Particle size and shape

The most widely used procedures to visualize microparticles are conventional light microscopy (LM) and scanning electron microscopy (SEM). Both can be used to determine the shape and outer structure of microparticles. LM provides a control over coating parameters in case of double walled microparticles. The microparticles structures can be visualized before and after coating and the change can be measured microscopically. SEM provides higher resolution in contrast to the LM. SEM allows investigations of the microparticles surfaces and after particles are cross-sectioned, it can also be used for the investigation of double walled systems.

Conflocal fluorescence microscopy is used for the structure characterization of multiple walled microparticles. Laser light scattering and multi size coulter counter other than instrumental methods, which can be used for the characterization of size, shape and morphology of the microparticles (microsponges).

Morphology and surface topography of microsponges

For morphology and surface topography, prepared microsponges can be coated with gold-palladium under an argon atmosphere at room temperature and then the surface morphology of the microsponges can be studied by scanning electron microscopy (SEM). SEM of a fractured microsponge particle can also be taken to illustrate its ultra-structure.

Determination of loading efficiency and production yield

The loading efficiency (%) of the microsponges can be calculated according to the following equation:

% loading efficiency= actual drug content in microsponges/ Theoretical drug content ×100

% Production yield= Production yield/ Theoretical mass (polymer + drug) ×100

Compatibility studies

Compatibility of drug with reaction adjuncts can be studied by thin layer chromatography (TLC) and Fourier Transform Infra-red spectroscopy (FT-IR).

Effect of polymerization on crystallinity of the drug can be studied by powder X-ray diffraction (XRD) and Differential Scanning Colorimetry (DSC). For DSC approximately 5 mg samples can be accurately weighed into aluminum pans and sealed and can be run at a heating rate of 15 C/min over a temperature range 25–43^0 C in atmosphere of nitrogen.

Resiliency (viscoelastic properties) of microsponges can be modified to produce beadlets that is softer or firmer according to the needs of the final formulation. Increased cross-linking tends to slow down the rate of release.

Applications of microsponges with respect to their advantages [8]

Microsponge delivery systems are used to enhance the safety, effectiveness and aesthetic quality of topical prescription, over-the-counter and personal care products. Microsponges can be used in variety of applications. It is used mostly for topical and recently for oral administration. Some applications and their advantages are given below (Table 1):

Table 1: Applications of microsponges with respect to their advantages

S.No	Application	Advantages
1	Sunscreens	Long lasting product efficacy, with improved protection against sunburns and sun related injuries even at elevated concentration and with reduced irritancy and sensitization
2	Anti-acne e.g. Benzoyl peroxide	Maintained efficacy with decreased skin irritation and sensitization.
3	Anti-inflammatory e.g. hydrocortisone	Long lasting activity with reduction of skin allergic response and dermatoses.
4	Anti-dandruffs e.g. zinc pyrithione, selenium sulfide	Reduced unpleasant odour with lowered irritation with extended safety and efficacy.
5	Antipruritics	Extended and improved activity.
6	Skin depigmenting agents e.g. hydroquinone	Improved stabilization against oxidation with improved efficacy and aesthetic appeal.

Examples of microsponge drug delivery with their formulations [8]

Microsponge drug delivery is available in variety of formulations. There are some examples of microsponge drug delivery with drug and their formulation in Table 2.

Table 2: Examples of microsponge drug delivery with their formulations

Microsponge delivery systems	Drug	Disease
Gels	Benzoyl peroxide	Anti-Acne Treatment
	Fluconazole	Inflammation
	Mupirocin	Antibacterial Activity
	Diclofenac sodium	Inflammation
	Acyclovir	Viral Infections
	Hydroxyzine HCl	Urticaria and atopic dermatitis
	Terbinafine HCl	Anti-fungal
Lotions	Benzoyl peroxide	Anti-Acne Treatment
Creams	Hydroquinone and Retinol	Melanoma
Tablets	Indomethacin	Inflammation
	Paracetamol	Anti-pyretic
	Chlorpheniramine maleate	Hay Fever
	Ketoprofen	Musuloskeleton Pain
	Fenofibrate	Gout
	Meloxicam	Arthritis
Implants	Poly (DL-lactic-co-glycolic acid)	Skin tissue engineering
Grafts	Poly (lactic-co glycolic acid)	Cardiovascular surgery
Injection	Basic fibroblast growth facto	Growth factor

List of marketed products based on microsponges [1]

Following are the product name of some microsponges with their manufacturer and its pharmaceutical uses are given below (Table 3):

Table 3: List of marketed products based on microsponges

Product Name	Pharmaceutical Uses	Manufacturer
Glycolic Acid Moisturizer w/SPF 15	Anti-Wrinkles, soothing	AMCOL Health & Beauty Solution
Retin A Micro	Acne vulgaris	Ortho-McNeil Pharmaceutical, Inc.
Carac Cream, 0.5%	Actinic keratoses	Dermik Laboratories, Inc.
Line Eliminator Dual Retinol Facial Treatment	Anti-wrinkle	Avon
Retinol 15 Night cream	Anti-wrinkles	Sothys
Retinol cream	Helps maintain healthy skin	Biomedic
EpiQuin Micro	Hyper pigmentation	SkinMedica Inc
Sports cream RS and XS	Anti-inflammatory	Embil Pharmaceutical Co. Ltd.
Salicylic Peel 20	Excellent exfoliation	Biophora
Oil free matte block SPF 20	Sunscreen	Dermalogica
Lactrex™ 12% Moisturizing Cream	Moisturizer	SDR Pharmaceuticals, Inc
Dermalogica Oil Control Lotion	Skin protectant	John and Ginger Dermalogica Skin Care Products
Ultra-Guard	Protects baby‟s skin	Scott Paper Company

Works done on microsponge

The motive behind present work was to formulate and evaluate gel containing microsponges of

=diclofenac diethylamine to provide prolonged release for proficient arthritis therapy. Quasi-emulsion solvent diffusion method was implied using Eudragit RS-100 and microsponges with varied drug–polymer ratios were prepared. Microsponges were characterized by SEM, DSC, FT-IR, XRPD and particle size analysis, and evaluated for morphology, drug loading, *in-vitro* drug release and *ex-vivo* diffusion as well. There were no chemical interactions between drug and polymers used as revealed by compatibility studies outcomes. The drug polymer ratio reflected notable effect on drug content, encapsulation efficiency and particle size. Thus the formulated microsponge-based gel of diclofenac diethylamine would be a promising alternative to conventional therapy for safer and efficient treatment of arthritis and musculoskeletal disorders [9].

Microsponge containing ketotifen drug with three different proportions of ethyl cellulose and drug were obtained successfully using quasi-emulsion solvent diffusion method. These formulations were studied for particle size and physical characterization. These microsponges enriched gel formulation were prepared by using 2 and 3 % w/w of SCMC and studied for viscosity, pH, gel strength, spreadability, bioadhesive force, drug content, in vitro release, HPLC and SEM analysis. The viscosity of microsponges enriched gel was found to be in the range 1299 to 1600 centipoises. The maximum gel strength and mucoadhesive force was found to be up to (8.12 sec) and (32.32 dynes/cm^2) respectively. The formulations exhibited spreadability (22.88 g.cm/sec). The optimized formulations were able to release the drug up to 8 h [10].

The aim of the study was to produce mupirocin entrapped microsponges to control the release of the drug to the skin. Mupirocin microsponges were prepared using an emulsion solvent diffusion method. In order to optimize the microsponge formulation, factors affecting the physical properties of microsponges were determined. FT-IR and SEM was used to study the shape and morphology of microsponges. Mupirocin microsponges were then incorporated into a vanishing cream base for release studies. It was shown that the drug: polymer ratio, stirring rate, volume of external and internal phase influenced the particle size and drug release behavior of microsponges. The results showed that an increase in the ratio of the drug: polymer resulted in a reduction in the release rate of Mupirocin from microsponges. Kinetic analysis showed that the main mechanism of drug release was by Higuchi matrix- controlled diffusion [11].

The aim of present study was to produce naproxen entrapped micro porous micro particles (micro sponges) to control the release of the drug to the skin. Naproxen micro sponge was prepared using quasi emulsion solvent diffusion method. In order to optimize the micro sponge formulation, factors affecting the physical properties of micro sponges were determined. Compatibility of the drug with excipients was studied by FT-IR. Production yield, loading efficiency and surface

morphology of micro sponges were performed. It was shown that the drug: polymer ratio and stirring rate influenced the particle size and drug release behaviour of micro sponges. The results showed that, generally an increase in the ratio of the drug: polymer resulted control release rate of naproxen from micro sponges [12].

The aim of present study was to produce mometasone furoate entrapped microporous microparticles (microsponges) to control the release of the drug to the skin. Mometasone furoate microsponge was prepared using an emulsion solvent diffusion method. In order to optimize the microsponge formulation, factors affecting the physical properties of microsponges were determined. Compatibility of the drug with excipients was studied by FT-IR. Production yield, loading efficiency and surface morphology of microsponges were performed. It was shown that the drug: polymer ratio, stirring rate, volume of external and internal phase influenced the particle size and drug release behaviour of microsponges. The results showed that, generally an increase in the ratio of the drug: polymer resulted in a reduction in the release rate of mometasone furoate from microsponges [13].

The aim of the study was to produce Ethyl Cellulose microsponge loaded with Tioconazole gel which was able to control the release of Tioconazole to the vaginal tissue. Drug content, Encapsulation efficiency and Percentage yield as such 73.97±0.01, 92.15±0.02 and 81.57±2.87 were determined in the prepared microsponges. The Scanning electron microscopy (SEM) of microsponges showed that they were spherical in shape and contained pores. Tioconazole microsponges were then incorporated into gel for release studies. It was found that the 12 h *in-vitro* drug release study of microsponge was best studied by Korsmeyer Peppas model [14].

In the present work, paracetamol loaded eudragit based microsponges were prepared using quasi emulsion solvent diffusion method. The compatibility of the drug with various formulation components was established. The formulations were subjected to *in- vitro* release studies and the results were evaluated kinetically and statically. The in vitro release data showed a bi-phasic pattern with an initial burst effect. In the first hour drug release from microsponges was found to be between 17-30%. The cumulative percent release at the end of 8^{th} h was noted to be between 54-83%. The release kinetics showed that the data followed Higuchi model and the main mechanism of drug release was diffusion. The colon specific tablets were prepared by compressing the microsponges followed by coating with pectin: hydroxypropyl methylcellulose (HPMC) mixture. In vitro release studies exhibited that compression coated colon specific tablet formulations started releasing the drug at 6^{th} h corresponding to the arrival time at proximal colon. The study presents a new approach for colon specific drug delivery [15].

The purpose of the present study aims to design novel drug delivery system containing hydroxyzine hydrochloride microsponges and to prepare controlled release microsponge tablets. The Microsponge Delivery System is a unique technology for the controlled release of active agents, and it consists of porous polymeric microspheres, typically 10–50 μm in diameter. Microsponges of the drug were prepared by using polymer Methocel 10000cps and in combination with Eudragit-S 100, Eudragit-L 100, Eudragit-RL 100 and Eudragit-RS 100. These are prepared by oil in oil emulsion solvent diffusion method using acetone as dispersing solvent and liquid paraffin as the continuous medium. Magnesium stearate was added to the dispersed phase to prevent flocculation of polymeric microsponges. Compatibility of the drug with adjuncts was studied by FT-IR. Production yield, loading efficiency, particle size analysis, surface morphology and *in vitro* release studies were carried out. The microsponge formulation (F8) was found to be stable at 40^{O}C and 75% relative humidity with respect to particle size, loading efficiency and *in-vitro* drug release [16].

The purpose of this study was to design novel drug delivery system containing Lornoxicam microsponges. Microsponges containing Lornoxicam and Eudragit RS 100 were prepared by quasi emulsion solvent diffusion method. The effects of drug to polymer ratios on physical characteristics of the microsponges were investigated. Compatibility of drug with adjuncts was studied by FT-IR. Production yield, loading efficiency, particle size analysis, surface morphology and *in-vitro* release studies were carried out. The microsponges were compressed into tablets. Mechanically strong tablets were obtained owing to the plastic deformation of sponge-like structure of microsponges. The effects of different stirring rates, amount of solvent, amount of emulsifier used on the physical characteristics of the microsponges were investigated [17].

The purpose of this work was to develop a prolonged microsponge drug delivery system containing dicyclomine. Dicyclomine-loaded, Eudragit-based microsponges were prepared using a quasi-emulsion solvent diffusion method. The compatibility of the drug with formulation components was established by differential scanning calorimetry (DSC) and Fourier transform infra-red (FTIR). Process parameters were modulated to optimize the formulation. Shape and surface morphology of the microsponges were examined using scanning electron microscopy. The results of compatibility tests showed that no chemical interaction or changes took place during preparation of the formulations; furthermore, the drug was stable in all the formulations. In increase in drug: polymer ratio resulted in a reduction in the release rate of the drug from the microsponges. Kinetic analysis showed that the main mechanism of drug release was by Higuchi matrix controlled diffusion [18].

Objective study was to investigate mechanism of release of Clotrimazole microsponge loaded gel and compare with plain Clotrimazole gel so as to develop an extended release topical drug delivery system of Clotrimazole. Microsponges of Clotrimazole were prepared using Ethyl cellulose and PVA by emulsion solvent diffusion method. On the basis of pharmacotechnical evaluation microsponges with least particle size 36.84um with good rheological properties were formulated as Carbopol gel (F1-F7). *In-vitro* drug release data of Clotrimazole microsponge loaded Carbopol Gel in phosphate buffer 7.4 when analyzed by Graph Pad Prism software version 4.0 Scan Diego, USA best fitted the makoid banker model (R^2 value greater than 0.98) .The Korsmeyer-Peppas release exponent (n) ranged between 0.331-0.418, which confirmed diffusion as principle mechanism of drug release. The release mechanism further confirmed by calculating the ratio of exponents A/B ratio derived from Kopcha model [19].

The work was aimed to develop an enteric-coated hydroxypropyl methylcellulose (HPMC) capsules (ECHC) plugged with 5-fluorouracil (5-FU)-loaded microsponges in combination with calcium pectinate beads. The modified quasi-emulsion solvent diffusion method was used to prepare microsponges. A 32 factorial design was employed to study the formulation and the effects of independent variables (volume of organic solvent and Eudragit-RS100 content) on dependent variables (particle size, %entrapment efficiency, and %cumulative drug release). An *in-vitro* release study of ECHC was performed in simulated gastric fluid for 2 h, followed by simulated intestinal fluid for next 6 h and then in simulated colonic fluid (in the presence and absence of pectinase enzyme for further 16 h). The optimized formulation was subjected to *in-vivo* roentgenographic and pharmacokinetic studies in New Zealand white rabbits to analyze the *in-vivo* behavior of the developed colon-targeted capsules. Drug release was retarded on coating with Ed-S100 in comparison to a blend of Ed-S100: Ed-L100 coating. The percentage of 5-FU released at the end of 24 h from ECHC3 was 97.83 ± 0.12% in the presence of pectinase whereas in the control study, it was 40.08 ± 0.02%. Thus, enteric-coated HPMC capsules plugged with 5-FU-loaded microsponges and calcium pectinate beads proved to be a promising dosage form for colon targeting [20].

Erythromycin microsponges were prepared using quassi emulsion solvent diffusion method. Erythromycin microsponges were then incorporated into a Carbopol-940 gel prepared by hydrogel technique for release studies. The best formulation was found to be stable at room temperature for 3 months. Thus it was concluded that erythromycin can be formulated as microsponge gel that can release the drug upto 8h with reduced side effects [21].

The objective of present work was to formulate and evaluate Fluconazole (FLZ) microsponges using quasi emulsion solvent diffusion technique and microsponge gel by using carbopol. Microsponges containing FLZ were obtained successfully with different proportions of ethyl cellulose polymer (EC). The formulations were studied for particle size and physical characterization. The physical characterization of the microsponge formulations showed better loading efficiency and production yield. The formulations were prepared as gel in 0.5% w/w carbopol and studied for pH, viscosity, spreadability, drug content, and *in-vitro* release. All three microsponge gel formulations (i.e. FM7, FM8 and FM9) showed better results like pH between 6.5-7.0, viscosity between 62,800-62,768 cps, spreadability 2-6 cm/s and drug content of 76.20±0.02% to 96.41±0.01%. *In-vitro* diffusion studies of formulations were performed in Franz diffusion cell. Surface morphology by scanning electron microscopy showed micro-porous nature of microsponges. Sustained release was observed when compare with control formulation [22].

Present study was taken up to develop a topical formulation that releases the drug in controlled manner, reduce the side effects associated with topical drug delivery and improve product efficacy with aid of microsponges. Microsponges loaded with sertaconazole nitrate were prepared by using quasi emulsion solvent diffusion with five different proportions of the polymer (Eudragit RS 100). The developed microsponges were analyzed for particle size, production yield, entrapment efficiency and drug content. Scanning electron microscopic images of microsponges revealed that they are spherical in shape and contain pores. Pore structure analysis was done by using mercury intrusion porosimetry technique, which confirmed the porous nature of microsponges. Microsponges were then incorporated in to a 1% corbopol gel and evaluated for pH, drug content, texture profile analysis and *in-vitro* drug release. The batch F IV was found to be optimal as it shown 69.38% controlled drug release in 8 h that followed Higuchi model.[23]

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